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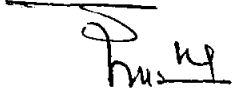
Subject: **Approval of Heat Rate for 97 MW Site Gas Turbine Power Station (SGTPS) of K-Electric (KE)**

Dear Sir,

Please find enclosed herewith subject Approval of the Authority (08 Pages) in the matter of Heat Rate for 97 MW Site Gas Turbine Power Station (SGTPS) of K-Electric Ltd. located at SITE area Karachi.

2. The subject Approval/Decision of the Authority is being intimated to the Federal Government for the purpose of notification in the official Gazette pursuant to Section 31(7) of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

Enclosure: As above


18 01 21

(Syed Safer Hussain)

Secretary
Ministry of Energy (Power Division)
'A' Block, Pak Secretariat
Islamabad

CC:

1. Secretary, Cabinet Division, Cabinet Secretariat, Islamabad.
2. Secretary, Ministry of Finance, 'Q' Block, Pak Secretariat, Islamabad.

ORDER

APPROVAL OF HEAT RATE FOR FOR 97 MW SGTPS OF K-ELECTRIC (KE)

Background:

Site Gas Engine Power Station (SGTPS) is a 97 MW power plant of K-Electric located in S.I.T.E area of Karachi. The Plant comprises 32 GEJB model JGS-620 Gas Engines (2.739MW each), 32 HRSGs and one Steam Turbine of 9.5MW rating (Model NG Allen MC-800 Brazil). The plant is configured in four (4) sections of 8 engines and 8 HRSGs each. Initially the plant was commissioned in open cycle in 2009 and later in 2016 was converted in Combined Cycle. The fuel for the plant is natural gas supplied by SSGC. The plant is connected to KE 132kV transmission system and is a part of the overall fleet of generating stations owned by K-Electric

Multi-Year Tariff (MYT) Determination of K-Electric Ltd:

2. The Authority in the matter of reconsideration request filed by the Federal Government regarding Multi-Year Tariff (MYT) petition of KE for the period commencing from July 1, 2016 to June 30, 2023 directed KE to conduct heat rate test of KCCPP, Site Gas Turbine Power Station (SGTPS) and Korangi Town Gas Turbine Power Station (KGTPS) and to submit report to the Authority for approval (Ref: Case # NEPRA/TRF-362/K-Electric-2016/10232-10234 dated July 5, 2018 - Paragraph 34 (viii), Page 49)

"In view of the addition of steam turbines at KCCP, SGTPS and KGTPS, the numbers in respect of efficiency and auxiliary consumption are worked on provisional basis, based on the given information and supporting documents. K-Electric is directed to conduct heat rate test of KCCP, SGTPS and KGTPS and submit the report to the Authority for approval. The adjustment in heat rates will be made based on the results of the performance (Heat Rate) test."

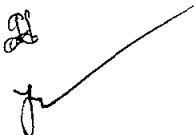
3. In order to test and evaluate the thermal performance of SGTPS, NEPRA directed KE to undertake a bidding process to procure the services of an Independent Engineer (IE) for conducting the performance test (Heat Rate and Capacity).

4. Pursuant to the above mentioned Authority's directions, KE procured the services of NESPAK-SGS for conducting the performance test (Heat Rate and Capacity) of SGTPS.

Objective of Performance (Capacity and Heat Rate) Test:

5. The main objective of this test as required by NEPRA was to evaluate the thermal performance (heat rate/thermal efficiency) and capacity of the plant on HHV and LHV as per ASME PTC-46 Standard in the following plant configurations:

- i. All four sections (32 engines, 32HRSGs and 01 Steam Turbine) in Base Load Combined Cycle Mode referred to as Primary Test # 1)



- ii. All four sections (32 engines) in open cycle Base Load referred to as Primary Test # 2)
- iii. Three sections (24 engines, 24HRSGs and 01 Steam Turbine) in Base Load Combined Cycle Mode referred to as Secondary Test # 1)
- iv. Two sections (16 engines, 16HRSGs and 01 Steam Turbine) in Base Load Combined Cycle Mode referred to as Secondary Test # 2)

Miscellaneous Additional Scope:

6. Authority vide letter to KE dated June 21, 2017 sought additional recommendations and analysis from Independent Engineer (IE) in Heat Rate report.

Test Standards:

7. The guidelines of following applicable standards were followed while preparing test procedure, conducting and evaluating the Heat Rate and Capacity test:

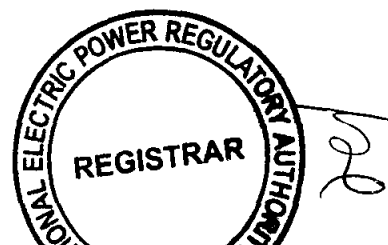
- **ASME PTC 46-2015** Overall Plant Performance
- **ISO-2314 2015** Gas Turbines - Acceptance Tests
- **ASTM D1945** Standard Test method for Analysis of Natural Gas Chromatography
- **ASTM D3588-98** Standard Practice for calculating heat value, compressibility factor, and relative density of gaseous fuels

Performance (Capacity and Heat Rate) Tests (July 06 - July 08, 2019):

8. Pursuant to the performance test procedures formulated and submitted by the Independent Engineer (IE) and thereafter approved by KE and agreed upon by NEPRA, the performance tests in different plant configuration were conducted on July 06 to July 08, 2019. During the course of data recording for Primary Test#1 duration-2, Engine#45 of section 4 tripped, resultantly test had to be stopped till the engine was synchronized and thereafter the test was continued for extra 30 minutes with mutual agreement of KE, NEPRA and IE as allowed under the code. For the performance test with all 4 sections at base load in combined cycle mode the results of each test run (the Gross/Net HHV/LHV Heat Rates and Gross/Net Capacities) were corrected to reference site conditions (RSC) and subsequently the corrected results of both test run were averaged. While for performance tests in open cycle mode, only one test of one hour duration was taken into consideration and the results (Heat Rate and Capacities) were corrected to reference site conditions (RSC) in accordance with the code.

Calculations of Calorific Values (LHV/HHV) of Gas fuel by IE:

9. All necessary arrangements for collection of Gas samples and their subsequent tests/analysis from an accredited laboratory for determination of composition including HHV/LHV

were made. A fuel gas sampling point was jointly identified prior to the test (Upstream line of section#2 gas flow meter). Special care was taken to ensure that the fuel sampling location was as far downstream of all filters as possible and closer to the Gas engines, so that the samples are true representation of the fuel actually being consumed by the Gas engines.

Test Results:

10. Following are the detailed results of test regarding capacity and heat rate of SGTPS as prepared by the IE and forwarded by KE to NEPRA on December 16, 2019.

- i. The CC Base Load Corrected (RSC) Net Heat rate (HHV) = 9063.865 Btu/kWh (37.646%);
- ii. Simple Cycle Corrected (RSC) Net Heat rate (HHV) = 9889.086 Btu/kWh (34.504%);
- iii. The Base Load, corrected RSC Gross Output is 96.191MW.
- iv. The Base Load, corrected RSC Net Output is 92.727MW.
- v. The Base Load (CC mode) Auxiliary Consumption is 3.476MW (3.599%).

Request of K-Electric:

11. Through its letter dated December 16, 2019 KE has requested following heat rates for approval.

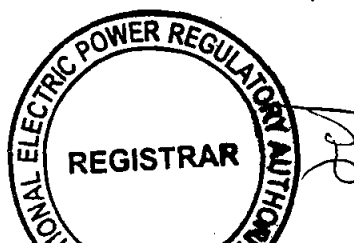
Financial Year	Net HHV Heat Rate ¹ (Btu / kWh)
2017 ²	9,179
2018 ²	9,240
2019	9,237
2020	9,318
2021	9,319
2022	9,262
2023	9,291
Average for the control period (FY 17-23)	9,264

- 1. For further details and basis, please refer IE NESPAK's report.
- 2. FY 17 and 18, heat rates calculated based on Heat rate of FY 19, actual operating hours of the plant and degradation curve of the plant available in IE's report

Analysis:

12. Pursuant to the instructions of the Authority, the Independent Engineer (IE) has carried out the performance (capacity and heat rate) tests of SGTPS of KE as per ASME PTC 46 standard and code - these were also witnessed by the NEPRA representatives.

13. It may be noted that under KE MYT FY 2017~23, NEPRA had determined a provisional Heat Rate of 8492 (40.18%) for SGTPS. This Heat Rate was assumed based on the addition of Steam Turbine (ST) and provision of Combined Cycle (CC) mode in the complex. However, KE filed a review requiring flat Heat Rate of 8892 (38.37%) for the control period. KE further



provided detailed calculations in support of its request. The Authority in view of the grounds raised by KE, determined a provisional HR of 8746.02 (39.01%), and in order to pass maximum benefit of efficiency improvement [owing to addition of ST and CC mode] to the end consumer required KE to conduct Heat Rate test. It is also to be noted that Federal Government through its Reconsideration Request on behalf of KE did not contest the Heat Rate and auxiliary consumption allowed by the Authority as discussed above.

A record of Heat Rates at different stages is shown in the following Table:

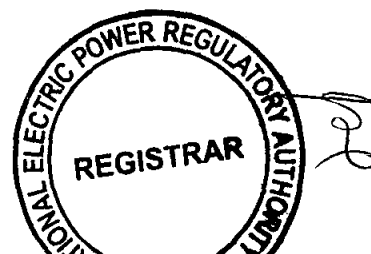
Description	Heat Rate (Corresponding Efficiency)
MYT 2016 Determined HR	8492 (40.18%)
KE Review Requested HR	8892 (38.37%)
KE Review – Determined HR	8746.02 (39.01%)
Reconsideration Request – HR (Net HHV)	No change in HR requested.
NEPRA determined Heat Rate after Reconsideration Request –Net HHV	8746.02 (39.01%)

14. The Heat Rate on the basis of test conducted on July 6, 2019 was noted as 9063.865 (corresponding efficiency of 37.646%) on Net HHV basis.

15. It is noted that the Heat Rate as a result of test on base load conditions is inferior to the Heat Rate provisionally allowed by NEPRA, however the Authority in its Determination on the Reconsideration Request by the GOP had decided that adjustment in Heat Rate will be made based on the result of Performance (Heat Rate) test. Therefore further clarification with the Independent Engineer (IE) and KE in this respect did not provide parameters for further corrections in the Heat Rate as a result of test.

16. Accordingly the Heat Rate as a result of test was analyzed in view of KE's requested numbers through its letter dated December 16, 2019. It is noted that KE has indicated separate heat rates for every year and worked out an average number for the seven year control period (FY 2017-2023). Analysis shows that the numbers represent heat rates corresponding to plant operation at 50% of the base-load levels.

17. The Authority notes that Gas engine based power plants due to multiple units and smaller size can maintain their operations at or very close to full capacity(100% load) and a single heat rate may be considered for SGTPS, which contains 32 generators of 2.739 MW each.



Authority however, also noted that there are externalities of gas availability and pressure which have been affecting KE operations in the past and it is expected that the gas availability and pressure would continue to impact KE's operations in the future also.

18. The Authority has also gone over the record provided by IE, of gas supply conditions to SGTPS and observed that over the last couple of years the plant could not be operated at all or at full load and that part-load operations were required frequently due to non-availability of gas or lower pressure of gas than the required minimum levels.

19. The Authority therefore principally agrees that KE be allowed part-load operations and heat rate shall be allowed to reflect such scenario. The Authority however is also cognizant of the fact that KE cannot be allowed a free hand to run its power plant at lower levels than is absolutely essential and under those conditions which are not controllable by KE. Therefore the Authority does not agree with KE's contention to allow heat rates corresponding to 50% of the base load levels. In order for KE to achieve better efficiencies while operating on part load, the Authority in addition to heat rates at 100% base loads decides to allow heat rates corresponding to 75% part load operation. Authority expects that KE shall make every endeavour to operate its power plants at higher loading conditions.

Heat Rate for the Control Period July 2016-June 2023

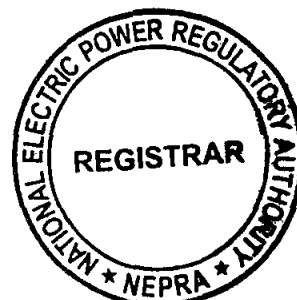
20. Heat Rate test was conducted in July 2019, however in view of seven year control period under MYT i.e. FY 2017-2023 it is necessary to make adjustments for:

1. July 2016 to June 2019
2. July 2019 till June 2023.

Heat Rate for period July 2016 to June 2019

21. The Authority notes that the Independent Engineer (IE) has evaluated Heat Rates for year FY 2017 and FY 2018 in addition to evaluation of annual Heat Rates for the remaining life of plant. Since IE and KE could not make EPC guaranteed values available, the Authority has decided that IE's evaluated numbers may be considered for the purpose.

22. In view of the decision of the Authority to allow heat rate at 75% loading conditions in addition to 100% loading, the Authority has relied upon the working of IE as it is noted that IE has evaluated Heat Rates at different loading positions of the plant i.e. at 50% loading (2 sections in CC mode), at 75% loading (3 sections at CC mode) and 100% (4 sections in CC mode).



23. Consequently IE's evaluated Heat Rate numbers for 100% loading (4 sections in CC mode) as well as 75% loading (3 sections in CC mode) for FY 2017, FY 2018 and FY 2019 are averaged to work out corresponding Heat Rate for the period July 2016 to June 2019.

Adjusted Heat Rate net HHV - (Btu / kWh)		Corresponding Efficiency
100% loading	9045.93	37.72%
75% loading	9064.794	37.642%

24. For transparency of applicability of either of the above Heat Rates - KE shall submit relevant data/documents on monthly basis. The relevant submissions shall include hourly energy generation and gas data (pressure, consumption, etc.) considered over a relevant month for verification of Part load operation or otherwise.

HEAT RATE Evaluation for July 2019- June 2023:

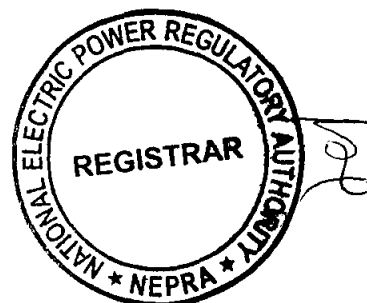
25. For the period July 2019 to June 2023, the IE's evaluated HR for July 2019 is adjusted for average degradation curve of the plant as indicated by IE for plant loading at 100% and 75% (i.e. 3 sections at CC mode).

IE evaluated Heat rate net HHV -(Btu / kWh)		Adjusted Heat rate net HHV- (Btu / kWh)	Corresponding Efficiency
100% loading	9063.865	9077	37.59%
75% loading	9082.767	9095.92	37.512%

26. For transparency of applicability of either of the above Heat Rates - KE shall submit relevant data/documents on monthly basis. The relevant submissions shall include hourly energy generation and gas data (pressure, consumption, etc.) considered over a relevant month for verification of Part load operation or otherwise.

Summary of Heat Rates / Efficiency Values allowed for SGTPS:

27. The Heat Rate numbers requested by KE and allowed by the Authority for SGTPS are summarized in the following table:



Heat Rate for July 2016 ~ June 2019

Requested by KE:

Plant	Net HHV Heat Rate (Btu/kWh) at RSC	Corresponding Efficiency
SGTPS	9264 ¹	36.83%

1. Average of 7 year Heat Rate (FY 2017-23) corresponding to 50% loading (2 sections in CC mode)

Allowed:

Plant	Net HHV Heat Rate (Btu/kWh) at RSC		Corresponding Efficiency
SGTPS	100% loading	9045.93	37.72%
	75% loading	9064.794	37.642%

Heat Rate for July 2019 ~ June 2023

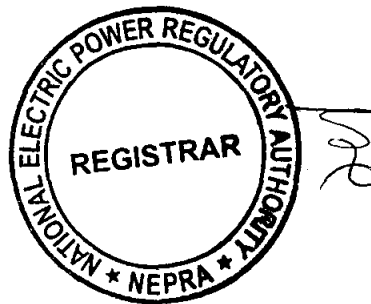
Requested by KE:

Plant	Net HHV Heat Rate (Btu/kWh) at RSC	Corresponding Efficiency
SGTPS	9264 ¹	36.83%

1. Average of 7 year Heat Rate (FY 2017-23) corresponding to 50% loading (2 sections in CC mode)

Allowed:

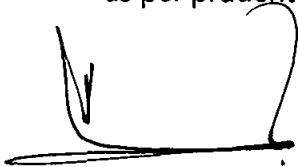
Plant	Net HHV Heat Rate (Btu/kWh) at RSC		Corresponding Efficiency
SGTPS	100% loading	9077	37.59%
	75% loading	9095.92	37.512%



Decision of the Authority:

Based on the Heat Rate tests conducted by the Independent Engineer for SGTPS, the Authority decides as follows;

- i. For the period from July 2016 to June 2019, the Heat Rates shall be allowed
 - For 100% load Heat Rate of 9045.93 Btu/kWh (Net HHV basis) corresponding to 37.72% efficiency.
 - For 75% load Heat Rate of 9064.794 Btu/kWh (Net HHV basis) corresponding to 37.642% efficiency
- ii. For the period from July 2019 to June 2023, the Heat Rates shall be allowed
 - For 100% load Heat Rate of 9077 Btu/kWh (Net HHV basis) corresponding to 37.59% efficiency.
 - For 75% load Heat Rate of 9095.92 Btu/kWh (Net HHV basis) corresponding to 37.512% efficiency.
- iii. For any plant operation above 75% of plant load, the Heat Rate corresponding to 100% load shall be applicable, whereas for operation of plant at or below 75% loading, Heat Rate allowed for 75% loading shall be applicable.
- iv. KE shall submit hourly record of power plant operations and corresponding gas data (pressure, consumption, etc.) to the Authority to determine applicable Heat Rates along with relevant periods on monthly basis. The data for the requisite month must be submitted by the 10th day of the next month.
- v. KE shall ensure transparency in economic merit order operation of its power plants and maintain relevant record under all operating conditions.
- vi. KE is required to conduct maintenance including Major Overhaul of its plants / units as per prudent utility practices and recommendations of OEM.



(Engr. Bahadur Shah)
Member



(Rehmatullah Baloch)
Member

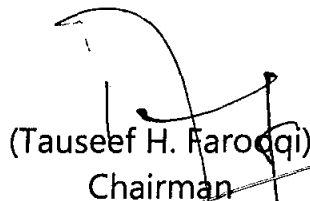


27/12/20

(Rafique Ahmed Shaikh)
Member



(Saif Ullah Chattha)
VC/Member



(Tauseef H. Farooqi)
Chairman

